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  - L1: (13624) (205/50-333).CCLS.
  - L2: (15908) (204/198-297.16).CCLS.
  - L3: (232) anode adj segments
  - L4: (27407) l1 or l2
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EAST Browser - L5: (36) 4 and 3 | US 5783058 | Tag: S | Doc: 1/36 (SORTED) | "Full" 3/10 (Total images 10)

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	Document ID	Pages	1	2	3	4	5	U	S	C	P	Kind Codes	Sou
1	US 5783058 A	10	☐	☐	☐	☐	☐	☐	☑	☐	☐		USPAT
2	US 5693202 A	12	☐	☐	☐	☐	☐	☐	☑	☐	☐		USPAT
3	US 5639358 A	12	☐	☐	☐	☐	☐	☐	☑	☐	☐		USPAT
4	US 5516411 A	11	☐	☐	☐	☐	☐	☑	☐	☐	☐		USPAT
5	US 5423961 A	11	☐	☐	☐	☐	☐	☑	☐	☐	☐		USPAT
6	US 5421987 A	13	☐	☐	☐	☐	☐	☑	☐	☐	☐		USPAT
7	US 5421968 A	13	☐	☐	☐	☐	☐	☑	☐	☐	☐		USPAT

DOCUMENT-IDENTIFIER: US 5783058 A
TITLE: Anode electroplating cell and method

---------- KWIC ---------

DRPR:
FIG. 3 is a plan view of the front face of a generally elongated light gauge sheet anode strip with optional bias cut anode segments along the anode length.

CLPR:
28. The apparatus of claim 17 wherein said strip anodes are bias cut into anode segments .

CLPR:
47. The anode of claim 39 wherein said strip anodes, along the length of said anodes, are bias cut into anode segments .

CCOR:
205/205

CCXR:
204/212

CCXR:
204/288.1

CCXR:
204/290.1

CCXR:
204/290.12

CCXR:
204/290.14

CCXR:
204/292

CCXR:
204/293

CCXR:
205/261

U.S. Patent Jul. 21, 1998 Sheet 2 of 2 5,783,058

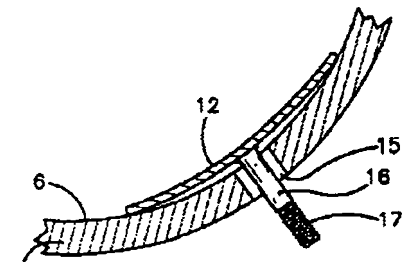

Fig.4

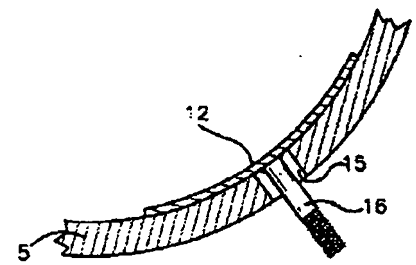

Fig.5

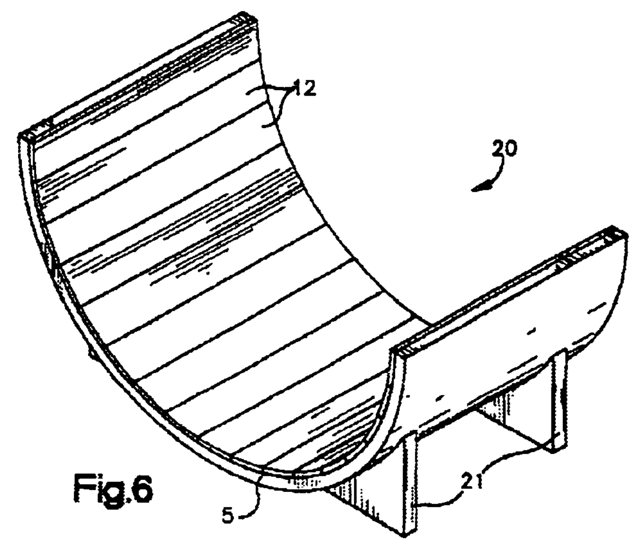

Fig.6

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EAST Browser - L5: (36) 4 and 3 | US 5322614 | Tag: S | Doc: 11/36 (SORTED) | "Full" 1/4 (Total images 4)

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	Document ID	Pages	1	2	3		4	U	S	C	P	Kind Codes	Sou
6	US 5421987 A	13							✓				USPAT
7	US 5421960 A	13							✓				USPAT
8	US 5411646 A	10							✓				USPAT
9	US 5393396 A	17							✓				USPAT
10	US 5384020 A	6							✓				USPAT
11	US 5322614 A	4							✓				USPAT
12	US 5281325 A	6						✓					USPAT

DOCUMENT-IDENTIFIER: US 5322614 A
TITLE: Device for electrolytic deposition of metals on one or both sides of strips

---------- KWIC ---------

BSPR:
According to a preferred embodiment of the invention, the corresponding anode is subdivided into several segments of the same size, where the anode segments can be held in a holder, with clear segments or insulating pieces between them.

BSPR:
The use of an anode subdivided into multiple segments in the direction of motion of the strip, according to the invention, allows several possibilities of controlling one-sided coating operation. With certain anodes, for example anodes made of iridium dioxide, it can be practical to apply a voltage which is less than that required to trigger deposition, to the individual segments of the anode segments which are voltage-free, in other words not "working," in order to prevent from passivating the anode and, at the same time, coating of the side of the strip which is not supposed to be coated. In the individual anode segments, a suitable application of charge to the anode can be controlled.

BSPR:
It is also possible, with a cathode according to the invention, if its surface consists of lead, for example, to reduce any precipitation which has formed on the side not to be coated, in one-sided operation, at the end of the strip segment passing through, by deposition in the reverse direction, in that such an electrical charge is applied to the anode segments in the area of the exit region, i.e. negative relative to the opposite strip segment, that reduction of the undesirable precipitation on the side of the strip which is not supposed to be coated takes place, without any significant deposition on the corresponding anode segment occurring.

DEPR:
While the insoluble anode 3 is to be viewed as homogeneous over its entire length, the other insoluble anode 4 is subdivided in the direction of motion of the strip, with parallel subdividing lines. These anode segments, which preferably have the same size, are designated with the numbers 41, 42, 43 and 44. These segments are insulated from one another, for example by the interstices between them, as shown. The anode segments are held in a holder designated with the number 7. However, the electrical insulation can also be brought about by insulating segments placed between them, for example plastic segments. An electrical charge can be applied to each anode segment, by separate connections 410, 420, 430, 440. With corresponding control processes, preferably regulated and monitored, different voltages or potentials can be applied to these segments, which serve to carry out one-sided coating of a strip via the anode 3.

CCOR:
205/96

CCXR:
205/130

CCXR:

United States Patent [19]
May et al.

[11] Patent Number: 5,322,614
[45] Date of Patent: Jun. 21, 1994

[54] DEVICE FOR ELECTROLYTIC DEPOSITION OF METALS ON ONE OR BOTH SIDES OF STRIPS

[76] Inventors: Hans J. May, Ulmenweg 17, D-5860 Iserlohn; Roland Schnettler, Schwerter Styr. 138, D-5800 Hagen, both of Fed. Rep. of Germany

[21] Appl. No.: 720,810

[22] PCT Filed: Jan. 20, 1990

[86] PCT No.: PCT/DE90/00035

§ 371 Date: Aug. 6, 1991

§ 102(e) Date: Aug. 6, 1991

[87] PCT Pub. No.: WO90/08209

PCT Pub. Date: Jul. 26, 1990

[30] Foreign Application Priority Data

Jan. 21, 1989 [DE] Fed. Rep. of Germany 3901807

[51] Int. Cl.[5] C25D 5/02; C25D 7/06

[52] U.S. Cl. 205/96; 205/130; 205/138

[58] Field of Search 205/96, 130, 138; 204/211

[56] References Cited

U.S. PATENT DOCUMENTS

3,523,166 7/1970 Jones 204/206
3,880,725 4/1975 Van Raalte et al. 204/15
3,970,537 7/1976 Froman et al. 204/211
4,240,881 12/1980 Stahya 204/28
4,347,115 8/1982 Eepenhahn et al. 204/205
4,597,837 7/1986 Oda et al. 204/14.1

FOREIGN PATENT DOCUMENTS

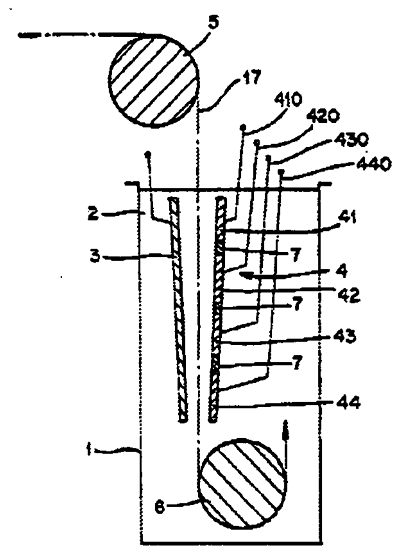
3017079 11/1981 Fed. Rep. of Germany .
63-259098 2/1989 Japan .
1-17890 5/1989 Japan .

Primary Examiner—John Niebling
Assistant Examiner—William T. Leader
Attorney, Agent, or Firm—Collard & Roe

[57] ABSTRACT

In a process for the electrolytic deposition of metal on one side of a strip, preferably a steel strip which forms the cathode, the section (7) of the strip to be coated is guided through a gap between two parallel anodes (3,4) which are insoluble in the electrolyte (6). A voltage can be applied to the anodes (3,4) independently of each other. One of the two anodes is subdivided perpendicular to the direction of motion of the strip into several sections (41, 42, 43, 44) electrically insulated from each other. Voltages are selectively and independently applied to the anode sections to prevent the side of the strip facing the anode sections from being permanently coated and to prevent passivation of the anode sections.

1 Claim, 1 Drawing Sheet



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EAST Browser - L5: (36) 4 and 3 | US 4828654 A | Tag: S | Doc: 21/36 (SORTED)

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18	US 5017275 A	9	☐	☐	☐	☐	☐	☑	☐	☐	☐		USPAT
19	US 4900410 A	13	☐	☐	☐	☐	☐	☑	☐	☐	☐		USPAT
20	US 4834845 A	11	☐	☐	☐	☐	☐	☑	☐	☐	☐		USPAT
21	US 4828654 A	8	☐	☐	☐	☐	☐	☐	☑	☐	☐		USPAT
22	US 4452683 A	7	☐	☐	☐	☐	☐	☑	☐	☐	☐		USPAT

DOCUMENT-IDENTIFIER: US 4828654 A
TITLE: Variable size segmented anode array for electroplating

---------- KWIC ---------

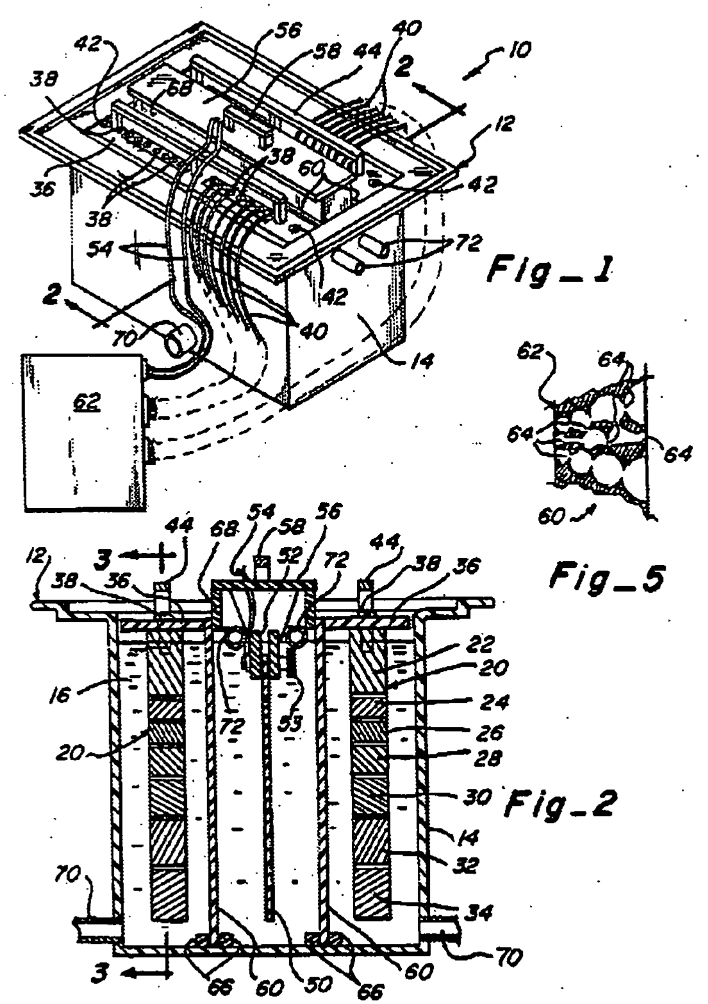
ABPL:
An anode used in electroplating is formed by a plurality of individual anode segments . The anode segments are arranged in predetermined patterns. The segments of certain patterns are selectively energized to establish an effective anode size that relates to the size of the article to be electroplated, thereby establishing an electrical field of uniform characteristics to transfer ions from the anode to the article at a uniform deposition rate over the whole surface of the article. By adjusting the effective size of the anode to correspond or relate to the size of the article, the non-uniform deposition rates associated with concentrated localized field are avoided, and the physical size of the electroplating apparatus can be reduced. An electrophoretic ion filter is also placed between the cathode and the article. This ion filter is preferably formed of a plastic porex material, such as porous polypropylene or polyethylene.

BSPR:
In accordance with one of the improvements available from the present invention, an anode is formed as an array of a plurality of individual anode segments arranged generally in a predetermined configuration. The anode segments of the configuration form a plurality of different-sized, predetermined patterns which increase in size from a center location of the anode array to the outer peripheral location of the anode array. Selected ones of the individual anode segments forming a selected pattern are selectively energized during the electroplating process. The size of the pattern and the ones of the anode segments which are energized are selected with reference to the size and aspect ratio of the article to be electroplated, thereby establishing a relatively comparable or somewhat smaller sized anode with respect to the size of the article to be electroplated. To accommodate a printed circuit board as an article to be electroplated, the anode array is preferably made planar. The distance separating the anode array from the printed circuit board may be made relatively small, in terms of a few inches, because the electroplating field from the selected and energized pattern of anode segments is substantially uniform at the surface of the printed circuit board, thereby avoiding the uneven buildup of electrolytically deposited material over certain areas of the circuit board. Also, adjusting the effective size of the anode has the effect of diminishing the need for relatively large physical dimensions of the electroplating bath, since the relatively large dimensions were previously employed to flatten or more uniformly distribute the electroplating field from the anode to the article.

DRPR:
FIG. 4 is an exploded perspective view of anode segments of an anode array shown in FIG. 3.

DEPR:
The electroplating apparatus 10 includes a pair of anodes, each of which is in the form of an anode array 20, shown in FIGS. 2, 3 and 4. Each anode array 20 includes a center anode segment 22 and a plurality of generally U-shaped anode segments 24, 26, 28, 30, 32 and 34. Each of the U-shaped anode segments generally nests within the adjoining outer U-shaped anode segment, while being separated only by relatively small space. The innermost center segment 22

U.S. Patent May 9, 1989 Sheet 1 of 2 4,828,654



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13	US 5188721 A	8	☐	☐	☐	☐	☐	☐	☑	☐	☐		USPAT
14	US 5188720 A	12	☐	☐	☐	☐	☐	☑	☐	☐	☐		USPAT
15	US 5164058 A	9	☐	☐	☐	☐	☐	☑	☐	☐	☐		USPAT
16	US 5156730 A	5	☐	☐	☐	☐	☐	☑	☐	☐	☐		USPAT
17	US 5098543 A	11	☐	☐	☐	☐	☐	☑	☐	☐	☐		USPAT

DOCUMENT-IDENTIFIER: US 5188721 A
TITLE: Plate anode having bias cut edges

---------- KWIC ---------

BSPR:
In a broad aspect, the invention is directed to an at least substantially planar shaped and inflexible anode structure containing fixed anode means having at least one face adapted for use in the electrodepositing of a coating on a moving cathode in sheet or strip form, which fixed anode means comprises a segmented plate anode having plate anode segments combining together to provide a broad, flat anode face for facing relationship with the moving sheet or strip cathode, the improvement comprising at least one anode segment having at least one bias cut edge, extending across the anode segment, which edge is bias cut in relation to the direction of travel of said cathode.

DEPR:
In reference to the drawings, the same identifying number has generally been used for the same element in each of the Figures. Referring to FIG. 1A, a prior art segmented plate anode is shown generally at 1. The anode as shown is made up of five plate anode segments 2. For purposes of simplicity of illustration, electrical supply means, anode support means and the like are not shown. In conjunction with a moving cathode, such cathode would be in movement across the faces of the anode segments in the direction represented in the Figure by the arrow A.

DEPR:
Also, as shown most particularly in the figures, it is contemplated that the bias cut edge will typically be at an acute angle to the path of travel of the metal strip. In the figures, these angles shown vary from about 40.degree. to about 70.degree.. Advantageously, these edges will be at an angle to the direction of the path of travel of the cathode of from about 30.degree. to about 70.degree.. Preferably, for most economical plate deposits such an angle will be from about 40.degree. to about 60.degree.. The plate anode segments may be positioned in a manner transverse to the path of travel of the moving cathode, as depicted by the center vertical line in FIG. 2, or may be positioned along the cathode travel path, in the manner as shown in FIG. 1A.

CLPR:
1. In an at least substantially broad faced and inflexible anode structure containing fixed anode means having at least one face adapted for use in the electrodepositing of a coating on a moving cathode in sheet or strip form, which fixed anode means comprises anode segments in plate form, each segment having width and length dimensions, said anode segments in plate form combining together to provide a broad anode face for facing relationship with said moving sheet or strip cathode, wherein the improvement comprises:

CLPR:
4. The anode structure of claim 1, wherein the opposing bias cut edges of said anode segments are separated by a non-insulated gap of from about 0.001 inch to about 0.03 inch.

CLPR:
7. The anode structure of claim 1, wherein said bias cut edge extends through said anode segments at an angle to the path of travel of said moving cathode of from about 30.degree. to about 70 .degree..

5,188,721

1

PLATE ANODE HAVING BIAS CUT EDGES

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of U.S. patent application Ser. No. 309,518, filed Feb. 10, 1989, now abandoned.

BACKGROUND OF THE INVENTION

The use of non-sacrificial anodes for the continuous electrolytic coating of large objects, e.g., metal plating of steel coils, is well known. A representative electrolytic deposition process is electrogalvanizing. For such deposition, a substrate metal, such as steel in sheet form feeding from a coil, is run through an electrolytic coating process, often at high line speed. It has been known to design the anodes for such a process wherein characteristics such as electrolyte flow as well as other dynamics must be taken into consideration.

For example in U.S. Pat. No. 4,642,173 an electrode has been shown which has been designed by taking into consideration not only the high power requirements for an electrogalvanizing operation, but also considering control and direction of electrolyte flow pattern. In the structure of the patent, elongated lamellar anodes are positioned by bar-shaped current distributors onto sheet connectors attached to a current feed post.

It has also been known in electrolytic electrogalvanizing operation to utilize platelike anodes. In U.S. Pat. No. 4,469,565, a metal strip in non-horizontal orientation is shown opposite a platelike anode. Electrodeposition proceeds by means of electrolyte flow between the strip cathode and the plate anode.

Where anode plates are used, and especially where metal strips of varying width are to be plated, plating around the edge of a narrow strip may be a problem. Because of this, it has been proposed in U.S. Pat. No. 4,119,515 to use inner, hourglass shaped plates, with complementary outer U-shaped plates, for adjusting the anode to varying strip widths without the need for anode replacement.

There is still, however, the need for anode structures that can be utilized in deposition operation such as electrogalvanizing, which structures provide for economy of operation, uniformity of deposition without striping or plate build-up at anode junctions, coupled with ease and economy in replacement or repair, including anode recoating. There is also need for anode structures of reliable electrical contact providing uninterrupted power supply, which supply is achieved without disruption of plate anode surface uniformity. For example, where an anode is placed in an electrolyte useful for electrogalvanizing a steel coil and the coiled steel is moving rapidly in front of, and close to, the anode face, it is highly desirable to maintain best uniformity for anode to cathode spacing.

SUMMARY OF THE INVENTION

An improved, highly efficient and rugged anode structure has now been constructed. The structure provides for desirably reduced striping or deposition build-up in coatings deposited on moving cathodes. The anode structure can be served by reliable electrical contact, but without disrupting anode surface uniformity.

In a broad aspect, the invention is directed to an at least substantially planar shaped and inflexible anode

2

structure containing fixed anode means having at least one face adapted for use in the electrodepositing of a coating on a moving cathode in sheet or strip form, which fixed anode means comprises a segmented plate anode having plate anode segments combining together to provide a broad, flat anode face for facing relationship with the moving sheet or strip cathode, the improvement comprising at least one anode segment having at least one bias cut edge, extending across the anode segment, which edge is bias cut in relation to the direction of travel of said cathode.

The plate anode can have a broad face that is generally flat or curvilinear, e.g., in concentric relationship with a curvilinear cathode.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A is a front elevational view of a segmented anode of the prior art.

FIG. 1 is a front elevational view of a bias cut anode of the present invention.

FIG. 2 is a front elevational view of a variant for a bias cut anode of the present invention.

FIG. 3 is a front elevational view of a still further variant of a bias cut anode of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The anode of the present invention can find particular utility in electrodeposition operation in an electrolytic cell wherein a deposit, e.g., a deposit of metal such as a zinc-containing deposit, is provided on a cathode. Exemplary of such operations is the electrogalvanizing of a substrate metal strip such as a steel strip. The anode can be particularly utilized in an electrodeposition operation wherein the cathode is a moving cathode, such as a moving sheet of steel as in an electrogalvanizing operation of coiled steel in strip form. For convenience, the anode may often be described herein in reference to use in an electrodeposition operation, and for illustrative purposes, such an operation may often be referred to as an electrogalvanizing operation. However, it is to be understood that the anode is contemplated for use in electrolytic cells utilizing other electrodeposition processes, e.g., the deposition of metals such as cadmium, nickel or tin, plus metal alloys as exemplified by nickel-zinc alloys, as well as in operations other than electrodeposition such as anodizing, electrophoresis and electropickling.

In reference to the drawings, the same identifying number has generally been used for the same element in each of the Figures. Referring to FIG. 1A, a prior art segmented plate anode is shown generally at 1. The anode as shown is made up of five plate anode segments 2. For purposes of simplicity of illustration, electrical supply means, anode support means and the like are not shown. In conjunction with a moving cathode, such cathode would be in movement across the faces of the anode segments in the direction represented in the Figure by the arrow A.

Referring then to FIG. 1, there is shown a bias cut plate anode 3 of the present invention. This plate anode 3, which would otherwise be generally rectangular in shape, does, however, have a bias cut edge 4. Electrical current is supplied to the anode 3 by current distributors, which may connect through buswork to an electrical power supply, all not shown. A second plate anode, also not shown, will have a bias cut edge for posi-

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14	US 5188720 A	12	☐	☐	☐	☐	☐	☐	☑	☐	☐		USPAT
15	US 5164058 A	9	☐	☐	☐	☐	☐	☐	☑	☐	☐		USPAT
16	US 5156730 A	5	☐	☐	☐	☐	☐	☐	☑	☐	☐		USPAT
17	US 5098543 A	11	☐	☐	☐	☐	☐	☑	☐	☐	☐		USPAT

DOCUMENT-IDENTIFIER: US 5156730 A
TITLE: Electrode array and use thereof

---------- KWIC ---------

BSPR:
Another aspect of the present invention is concerned with an electroplating apparatus that includes a housing which contains means defining a receptacle for a bath of an electroplating composition. An anode array is positioned within the receptacle to contact the bath. The anode array includes a plurality of individual anode segments . The anode segments are independently wired and physically separated from each other. A support means for supporting at least one article to be electroplated is provided in the receptacle and in the bath at a location spaced from the anode array. Means are provided for electrically biasing each of the anode segments individually and for controlling the quantity of current to each of the anode segments individually. Associated with the support means is means that are operative for electrically connecting the article to be coated to act as a cathode in an electroplating cell.

BSPR:
A still further aspect of the present invention is concerned with a method of electroplating an article. The method includes providing in a housing an anode array, the article to be coated spaced from the anode array and means associated with the article for electrically connecting the article to act as the cathode, and an electroplating bath. The anode array includes a plurality of individual anode segments . The anode segments are independently wired and physically separated from each other. Each of the anode segments is individually biased and the quantity of current supplied to each of the anode segments is individually preselected. An anodic current is conducted from the anode array to thereby electroplate the article.

DEPR:
Each of the anode segments is individually wired and physically separated from the other anode segments . The anode segments are physically separated from each other by an electrical non-conductor. Reference to FIG. 1 illustrates a schematic of a segmented anode configuration pursuant to the present invention whereby numeral 1 represents the various anode segments physically separated from each other by spacing 2 (i.e.--air acting as the non-conductor).

DEPR:
Each of the anode segments 1 are provided with means to individually electrically bias each segment and to control the quantity of the current supplied to each anode segment. Individually each of the segments can be selectively biased by employing circuitry that contains different sized resistors to change the current along with a simple switching devices. The particular multiplexor circuitry employed would be readily apparent to those skilled in the art once aware of the present disclosure and need not be discussed herein in any further detail.

DEPR:
The particular anode segments 1 shown in FIGS. 2 and 3 are platinized titanium mesh. However, each anode segment can be solid or in any mesh configuration desired.

DEPR:

US005156730A

United States Patent [19]

Bhatt et al.

[11] Patent Number: 5,156,730

[45] Date of Patent: Oct. 20, 1992

[54] ELECTRODE ARRAY AND USE THEREOF

[75] Inventors: Anilkumar C. Bhatt, Johnson City; Michael T. Freeman; John J. Konrad, both of Endicott; Narendra G. Shah, Johnson City, all of N.Y.

[73] Assignee: International Business Machines, Armonk, N.Y.

[21] Appl. No.: 720,677

[22] Filed: Jun. 25, 1991

[51] Int. Cl.[5] C25D 5/02

[52] U.S. Cl. 205/118; 204/231

[58] Field of Search 204/15, 231

[56] References Cited

U.S. PATENT DOCUMENTS

2,486,985	11/1949	Ruderfer	204/224 R
3,880,725	4/1975	Van Raalte	204/15
4,354,914	10/1982	Szeliga	204/224 R
4,367,125	1/1983	Beck	204/224 R
4,507,181	3/1985	Nath et al.	204/15
4,828,654	5/1989	Reed	204/23

FOREIGN PATENT DOCUMENTS

208499	8/1989	Japan .
418299	8/1974	U.S.S.R. .
703285	12/1979	U.S.S.R. .
724308	3/1980	U.S.S.R. .

OTHER PUBLICATIONS

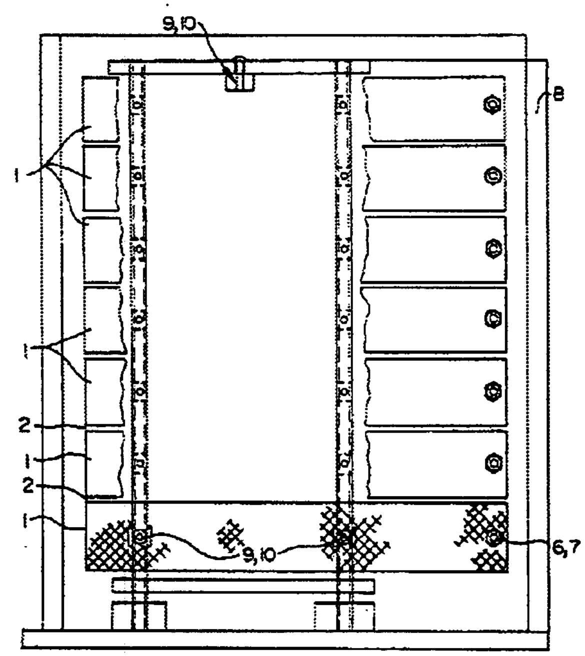
Micro-plate/systems, the drilling machines, PCPAB, Feb. 1991, p. 46.

Primary Examiner—T. M. Tufariello
Attorney, Agent, or Firm—Pollock, Vande Sande & Priddy

[57] ABSTRACT

An electrode array containing individual electrode segments having means to electrically bias each of the segments individually and to control the quantity of current supplied to each of the electrode segments individually; and use of the array.

5 Claims, 2 Drawing Sheets



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Drafts
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L2: (15908) (204/198-297.16).CCLS.
L3: (232) anode adj segments
L4: (27407) 11 or 12
L5: (36) 14 and 13
L6: (708) (adjust or adjusts or adjusted or adjusting or adjustable) near2 (anode or anodes)
L7: (254) 14 and 16
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EAST Browser - L9: (131) 4 and 8 | US 6306279 B1 | Tag: S | Doc: 3/131 (SORTED) | Format : KWIC

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1	US RE30864 E	10	☐	☐	☐	☐	☐	☐	☑	☐	☐		USPAT
2	US 6361677 B1	11	☐	☐	☐	☐	☐	☐	☑	☐	☐		USPAT
3	US 6306279 B1	6	☐	☐	☐	☐	☐	☐	☑	☐	☐		USPAT
4	US 6299751 B1	45	☐	☐	☐	☐	☐	☑	☐	☐	☐		USPAT
5	US 6296753 B1	45	☐	☐	☐	☐	☐	☑	☐	☐	☐		USPAT
6	US 6287443 B1	45	☐	☐	☐	☐	☐	☑	☐	☐	☐		USPAT
7	US 6277260 B1	45	☐	☐	☐	☐	☐	☑	☐	☐	☐		USPAT

DOCUMENT-IDENTIFIER: US 6306279 B1
TITLE: Anode cathode distance adjustment device

---------- KWIC ---------

BSPR:
In the process as generally practiced today, carbon is used as the anode. In a typical operation of a Hall cell using carbon as the electrode, it is desirable that the carbon be in a block form. The carbon block is consumed during the electrolytic process and a large block or mass minimizes the frequency with which electrodes must be replaced. During the process, the carbon is oxidized to primarily form CO.sub.2 which is given off as a gas. The oxidation occurs mainly along the bottom surface of the anode, adjacent to the cathode. As the block is oxidized, the distance between the anode and the cathode increases. To adjust to anode cathode distance, the anode was typically mounted on a rod which could be moved vertically. This vertical adjustment accounted for both the rise in the elevation of the cathode and the reduction of the anode. Because the rise in elevation of the molten aluminum is typically not as great as the reduction in the size of the anode, the anode was usually being slowly lowered into the salt bath.

BSPR:
These needs, and others, are addressed by the invention which provides a device for adjusting anode -cathode distance using a displacement device which cooperates with a sump to raise or lower the level of the molten metal thereby changing the anode-cathode distance.

CCXR:
204/243.1

CCXR:
204/245

CCXR:
204/250

(12) **United States Patent**
Kozarek

(10) **Patent No.: US 6,306,279 B1**
(45) **Date of Patent: Oct. 23, 2001**

(54) ANODE CATHODE DISTANCE ADJUSTMENT DEVICE

(75) Inventor: Robert L. Kozarek, Apollo, PA (US)

(73) Assignee: Alcoa Inc., Pittsburgh, PA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: 09/543,972

(22) Filed: Apr. 7, 2000

(51) Int. Cl.^{7} C25C 3/20

(52) U.S. Cl. 205/375; 205/378; 205/382; 204/243.1; 204/245; 204/250

(58) Field of Search 204/225, 243.1, 204/245, 250, 297.04; 205/375, 378, 382

(56) References Cited

U.S. PATENT DOCUMENTS

3,616,432 * 10/1971 Day 204/245

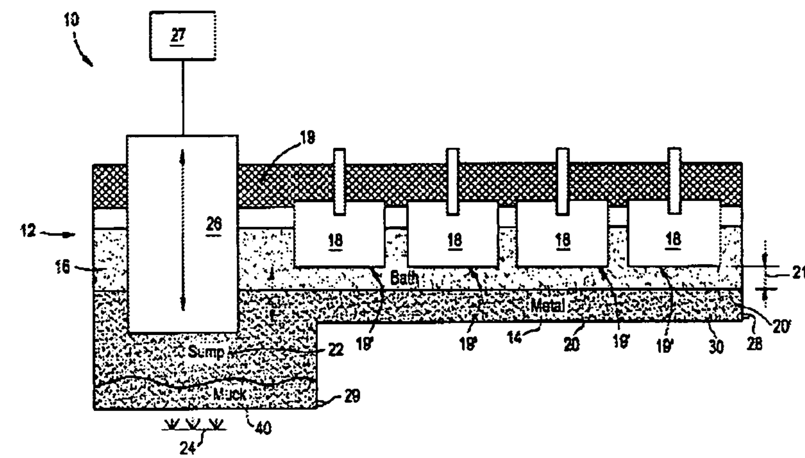
* cited by examiner

Primary Examiner—Bruce F. Bell
(74) *Attorney, Agent, or Firm*—Glenn E. Klepac

(57) ABSTRACT

A device for adjusting the distance between the anode and the cathode of an electrolytic cell having a compartment, at least one anode partially disposed in a molten metal producing salt bath and a layer of molten metal above a cathode. The device includes a displacement device partially disposed within the layer of molten metal, and an actuator to move the displacement device generally vertically.

30 Claims, 1 Drawing Sheet



6/2002

EAST Browser - L9: (131) 4 and 8 | US 4855020 | Tag: S | Doc: 42/131 (SORTED) | "Full" 1/24 (Total images 24)

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	Document ID	Pages	U	S	Source
38	US 5089093 A	26		☑	USPAT
39	US 4915796 A	11		☑	USPAT
40	US 4871435 A	12		☑	USPAT
41	US 4865701 A	8		☑	USPAT
42	US 4855020 A	24		☑	USPAT
43	US 4818353 A	17		☑	USPAT
44	US 4670110 A	21	☑		USPAT

DOCUMENT-IDENTIFIER: US 4855020 A
TITLE: Apparatus and method for the electrolytic plating of layers onto computer memory hard discs

---------- KWIC ---------

DEPR:
After experimentation, it was found to be important to individually control each of the anodes 16. It was particularly true where the anode vessel configuration was used. In situations where the anodic pellets within the vessel shift position or rearrange themselves, it is possible that resistance could be increased or other distortions occur in current flow. By being able to individually adjust each of these anodes, corrections can be made without rearrangement of the anodic pellets or other mechanical repair to the system.

CCOR:
205/137

CCXR:
204/212

CCXR:
204/218

CCXR:
204/230.3

CCXR:
204/230.7

CCXR:
205/148

United States Patent [19]

Sirbola

[11] Patent Number: 4,855,020

[45] Date of Patent: * Aug. 8, 1989

[54] APPARATUS AND METHOD FOR THE ELECTROLYTIC PLATING OF LAYERS ONTO COMPUTER MEMORY HARD DISCS

[75] Inventor: Michael A. Sirbola, Houston, Tex.

[73] Assignee: Microsurface Technology Corp., Houston, Tex.

[*] Notice: The portion of the term of this patent subsequent to Jan. 19, 2005 has been disclaimed.

[21] Appl. No.: 144,019

[22] Filed: Jan. 12, 1988

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 806,081, Dec. 6, 1985, Pat. No. 4,720,329, and a continuation-in-part of Ser. No. 651,493, Sep. 17, 1984, abandoned.

[51] Int. Cl.[4] C25D 7/00; C25D 17/00

[52] U.S. Cl. 204/23; 204/212; 204/218; 204/228; 204/DIG. 7; 360/135

[58] Field of Search .... 204/23, 212, 215, 216, 204/217, 218, 5, 228, DIG. 7; 360/135

[56] References Cited

U.S. PATENT DOCUMENTS

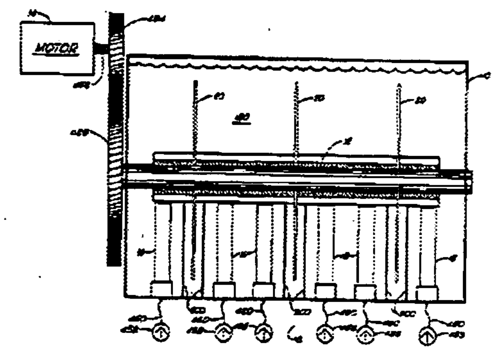
526,482	9/1894	Bridgman	204/212
1,029,965	6/1912	Aylsworth	204/5 X
1,073,868	9/1913	Perreur et al.	204/212
1,347,088	7/1920	Greenawalt	204/212
2,438,885	4/1948	Bell	204/212
2,675,348	4/1954	Greenspan	204/5 X
3,236,757	2/1966	Litt	204/212 X
3,470,082	9/1969	Raymond et al.	204/228
4,144,160	3/1979	Faulkner	204/212
4,304,641	12/1981	Grandia et al.	204/23
4,359,375	11/1982	Smith	204/212
4,415,423	11/1983	Brooks	204/212
4,720,329	1/1988	Sirbola	204/23

Primary Examiner—G. L. Kaplan
Attorney, Agent, or Firm—Harrison & Egbert

[57] ABSTRACT

An apparatus for the electrolytic plating of computer memory discs comprising a plating container for the receipt of a liquid plating bath, a spindle fitted to the plating container, a prime mover connected to the spindle for causing relative rotational movement, a fixed and non-translatable stationary anode attached to the plating container, an electrical transmission system connected to the spindle and to the anode, and suitable current distribution controllers positioned within the plating container. The spindle has a receiving area for fixing to the inner diameter of a computer memory disc. The stationary anode is positioned on opposite sides of the receiving area of the spindle. The electrical transmission system includes a contact surface for establishing electrical contact with the edge of a computer memory disc. The current distribution controllers are adjacent the contact surface of the electrical conductors.

42 Claims, 11 Drawing Sheets



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53	US 4460440 A	6							☑				USPAT
54	US 4459194 A	12							☑				USPAT
55	US 4455208 A	11							☑				USPAT
56	US 4448660 A	4							☑				USPAT
57	US 4440614 A	8							☑				USPAT
58	US 4436607 A	6							☑				USPAT
59	US 4427519 A	6						☑					USPAT

DOCUMENT-IDENTIFIER: US 4436607 A
TITLE: Anode superstructure of a fused salt electrolytic cell and pot room fitted out with same

---------- KWIC ---------

DEPR:
In the present example the level of the anodes is adjusted pairwise; each pair of anode rods 32 is releasably attached to an anode beam 34. These beams 34 can be displaced in the vertical direction by means of a jacking system 36 comprising essentially a step-down gearing facility 38 which operates on a spindle, not visible here, in a spindle housing 40.

CCOR:
204/246

CCXR:
204/247

CCXR:
204/279

United States Patent [19]

Fischer

[11] 4,436,607

[45] Mar. 13, 1984

[54] ANODE SUPERSTRUCTURE OF A FUSED SALT ELECTROLYTIC CELL AND POT ROOM FITTED OUT WITH SAME

[75] Inventor: Werner K. Fischer, Venthône, Switzerland

[73] Assignee: Swiss Aluminium Ltd., Chippis, Switzerland

[21] Appl. No.: 394,115

[22] Filed: Jul. 1, 1982

[30] Foreign Application Priority Data

Jul. 14, 1981 [CH] Switzerland 4598/81

[51] Int. Cl.³ C25C 3/10; C25C 3/22

[52] U.S. Cl. 204/246; 204/247; 204/279

[58] Field of Search 204/243 R-247, 204/67, 279, 286

[56] References Cited

U.S. PATENT DOCUMENTS

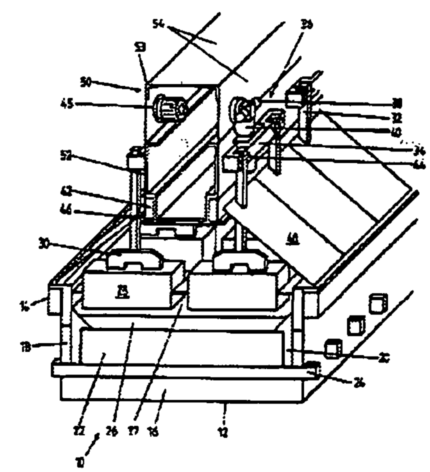
2,861,036 11/1958 Simon-Suisse .... 204/243 R
3,575,827 4/1971 Johnson .... 204/247 X
3,607,685 9/1971 Johnson .... 204/244 X
4,045,892 8/1977 Gonzalez et al. 204/247
4,097,345 5/1978 Sandvik et al. .... 204/243 R

Primary Examiner—Donald R. Valentine
Attorney, Agent, or Firm—Bachman and LaPointe

[57] ABSTRACT

Conventional fused salt reduction cells feature anode conductor sections which are spaced apart and have the function of feeding electric current to the anodes via anode rods. An electrically insulated footbridge positioned over the cell between the anode conductor sections makes it possible to walk above the cell. A housing with slight positive pressure created by the supply of fresh air to it, is preferably provided over this footbridge. Transverse cells are arranged asymmetrically in a pot room. An air-tight, closable walk-way i.e. gangway is provided on the inside or outside of the long wall of the pot room. Extensions to the cell housings lead to appropriate openings in the long wall of the pot room or to the longitudinal wall of a gangway in the interior of the pot room. The fresh air is passed through the gangway and emerges from the open end of the cell housing.

11 Claims, 2 Drawing Figures



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EAST Browser - L9: (131) 4 and 8 | US 5326455 | Tag: S | Doc: 31/131 (SORTED) | "Full" 4/13 (Total images 13)

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29	US 5366605 A	9	☐	☐	☐	☐	☐	☐	☑	☐	☐		USPAT
30	US 5336378 A	11	☐	☐	☐	☐	☐	☐	☑	☐	☐		USPAT
31	US 5326455 A	13	☐	☐	☐	☐	☐	☐	☑	☐	☐		USPAT
32	US 5314608 A	14	☐	☐	☐	☐	☐	☑	☐	☐	☐		USPAT

DOCUMENT-IDENTIFIER: US 5326455 A
TITLE: Method of producing electrolytic copper foil and apparatus for producing same

---------- KWIC ---------

DEPR:
A copper foil 35 .mu.m thick (nominal thickness, 1 ounce/ft.sup.2) was made using a copper sulfate solution and a combination of a cathode drum 2.0 m in diameter and 1.3 m wide and two 1.3 m wide anode sheets arranged arcuately along substantially the lower half of the cathode drum as shown in the drawings. The anode structure according to the invention was as depicted in FIGS. 3 and 4 and comprised 30 sub-anodes. On the basis of the weight values per unit area of the peeled copper foil, the electric currents supplied to the individual sub-anodes were adjusted within the range of 0.1 to 10 A/dm.sup.2. Thus, the method of the invention rendered it possible to reduce the variation in thickness widthwise, from the usual level of about 4.5% down to 0.5% or less as shown in FIGS. 6 and 7, respectively, where the thicknesses at points 1 to 16 in the half-width sections of the foils made according to this invention and conventionally were measured in terms of weight per unit area (g/m.sup.2).

CCOR:
205/77

CCXR:
204/211

CCXR:
205/84

CCXR:
205/96

U.S. Patent July 5, 1994 Sheet 3 of 5 5,326,455

FIG.3

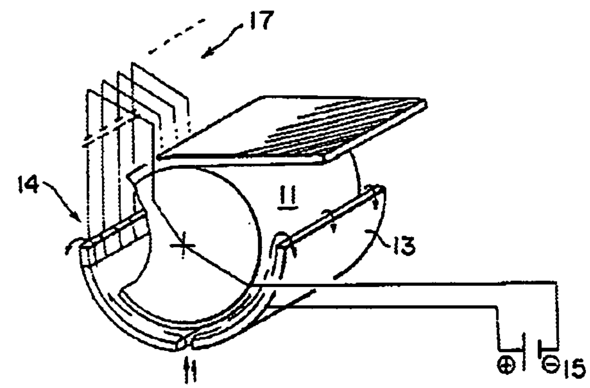
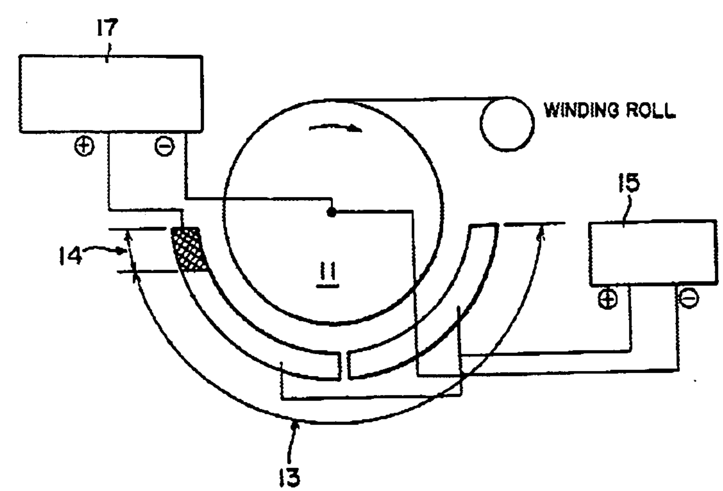


FIG.4



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concentric near2 anodes

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DBs: USPAT; US-PGPUB

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1	☑	☐	☐	☐	US 20030159921 A1	20030828	37	Apparatus with processing stations for manually and	204/224R	204/198; 204/471	204/224R	Harris, Randy et al.	☐	☐	☐	☐	☐	☐
2	☑	☐	☐	☐	US 20030146107 A1	20030807		Method and device for the production of pipe segments	205/670	204/224M; 204/224R;	204/224R	Van Oirschot, Cornelus Hendricus Maria et al.	☐	☐	☐	☐	☐	☐
3	☑	☐	☐	☐	US 20030146089 A1	20030807		Plating method and apparatus that creates a differential	204/224R	204/227	204/224R	Basol, Bulent	☐	☐	☐	☐	☐	☐
4	☑	☐	☐	☐	US 20030127337 A1	20030710		Apparatus and methods for electrochemical processing	205/96	204/224M; 204/224R;	204/224R	Hanson, Kayle M. et al.	☐	☐	☐	☐	☐	☐
5	☑	☐	☐	☐	US 20030085118 A1	20030508		Semiconductor wafer plating cell assembly	204/224R	204/263	204/224R	Tench, D. Morgan et al.	☐	☐	☐	☐	☐	☐
6	☑	☐	☐	☐	US 20030062271 A1	20030403		Method and apparatus for selectively removing	205/717	204/224R; 204/267;	204/224R	Kool, Lawrence Bernard et al.	☐	☐	☐	☐	☐	☐
7	☑	☐	☐	☐	US 20030057098 A1	20030327		Plating apparatus and method	205/143	204/199; 204/224R;	204/224R	Sendai, Satoshi et al.	☐	☐	☐	☐	☐	☐
8	☑	☐	☐	☐	US 20030051995 A1	20030320		Plating device and plating method	204/199	204/224R; 204/225;	204/224R	Nobata, Hirotaka et al.	☐	☐	☐	☐	☐	☐
9	☑	☐	☐	☐	US 20030024819 A1	20030206		Method of providing conductive tracks on a	205/117	204/224R; 205/118	204/224R	Lowe, John Michael	☐	☐	☐	☐	☐	☐
10	☑	☐	☐	☐	US 20030019741 A1	20030130		Method and apparatus for sealing a substrate surface	204/224R	118/400; 204/297.01	204/224R	Kholodenko, Arnold V. et al.	☐	☐	☐	☐	☐	☐
11	☑	☐	☐	☐	US 20020153256 A1	20021024		Method and apparatus for depositing and controlling	205/117	204/224R; 205/222	204/224R	Uzoh, Cyprian Emeka et al.	☐	☐	☐	☐	☐	☐
12	☑	☐	☐	☐	US 20020139682 A1	20021003		Method and apparatus for avoiding particle	205/117	204/212; 204/224R;	204/224R	Basol, Bulent M. et al.	☐	☐	☐	☐	☐	☐

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40	US 6358388 B1	59	☐	☐	☐	☐	☐	☐	☑	☐	☐		USPAT
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42	US 6344126 B1	6	☐	☐	☐	☐	☐	☐	☑	☐	☐		USPAT
43	US 6344125 B1	8	☐	☐	☐	☐	☐	☐	☑	☐	☐		USPAT
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US-PAT-NO: 6332963

DOCUMENT-IDENTIFIER: US 6332963 B1

TITLE: Cup-type plating apparatus and method for plating wafer using the same

---------- KWIC ---------

Current US Cross Reference Classification - CCXR (3):
205/123

(12) **United States Patent**
Sakaki et al.

(10) Patent No.: **US 6,332,963 B1**
(45) Date of Patent: **Dec. 25, 2001**

(54) **CUP-TYPE PLATING APPARATUS AND METHOD FOR PLATING WAFER USING THE SAME**

(75) Inventors: **Yasuhiko Sakaki**, Hiratsuka; **Mika Kurihara**, Hadano, both of (JP)

(73) Assignee: **Electroplating Engineers of Japan Limited**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/404,752**

(22) Filed: **Sep. 24, 1999**

(51) Int. Cl.[7] **C25B 9/00**

(52) U.S. Cl. .... 204/266; 204/263; 204/224 R; 205/123; 205/148

(58) **Field of Search** .... 204/224 R, 266, 204/252, 280, 286.1, 287, 263, 275.1; 205/148, 123, 122

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,113,759 * 9/2000 Uzoh 204/285

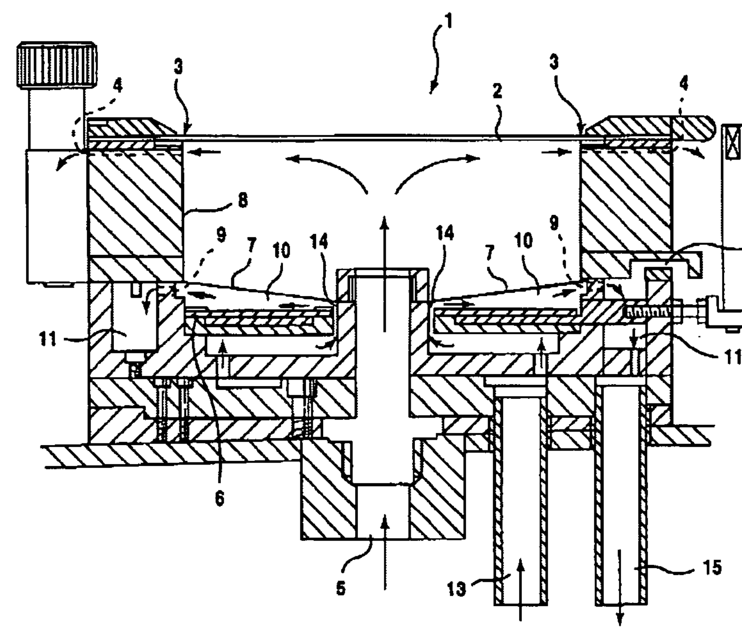
* cited by examiner

Primary Examiner—Bruce F. Bell
(74) *Attorney, Agent, or Firm*—Arent Fox Kintner Plotkin & Kahn, PLLC

(57) **ABSTRACT**

A cup-type plating apparatus includes a plating tank having a support section provided on an upper end thereof for holding a wafer; a solution feed section provided at the center of a bottom portion of the plating tank; an anode disposed within the plating tank; and a diaphragm for separating the anode from the wafer. The diaphragm is slanted upward from the solution feed section toward the periphery of the plating tank. A gas release port is provided in the plating tank at such a position as to release bubbles collected under an upper end portion of the diaphragm.

3 Claims, 1 Drawing Sheet



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26	US 6454926 B1	63	☐	☐	☐	☐	☐	☐	☑	☐	☐		USPAT
27	US 6448644 B1	15	☐	☐	☐	☐	☐	☐	☑	☐	☐		USPAT
28	US 6444110 B1	7	☐	☐	☐	☐	☐	☐	☑	☐	☐		USPAT
29	US 6440289 B1	9	☐	☐	☐	☐	☐	☐	☑	☐	☐		USPAT
30	US 6436267 B1	22	☐	☐	☐	☐	☐	☐	☑	☐	☐		USPAT

US-PAT-NO: 6436267

DOCUMENT-IDENTIFIER: US 6436267 B1

TITLE: Method for achieving copper fill of high aspect ratio interconnect features

---------- KWIC ---------

Current US Cross Reference Classification - CCXR (1):
205/123

U.S. Patent Aug. 20, 2002 Sheet 4 of 8 US 6,436,267 B1

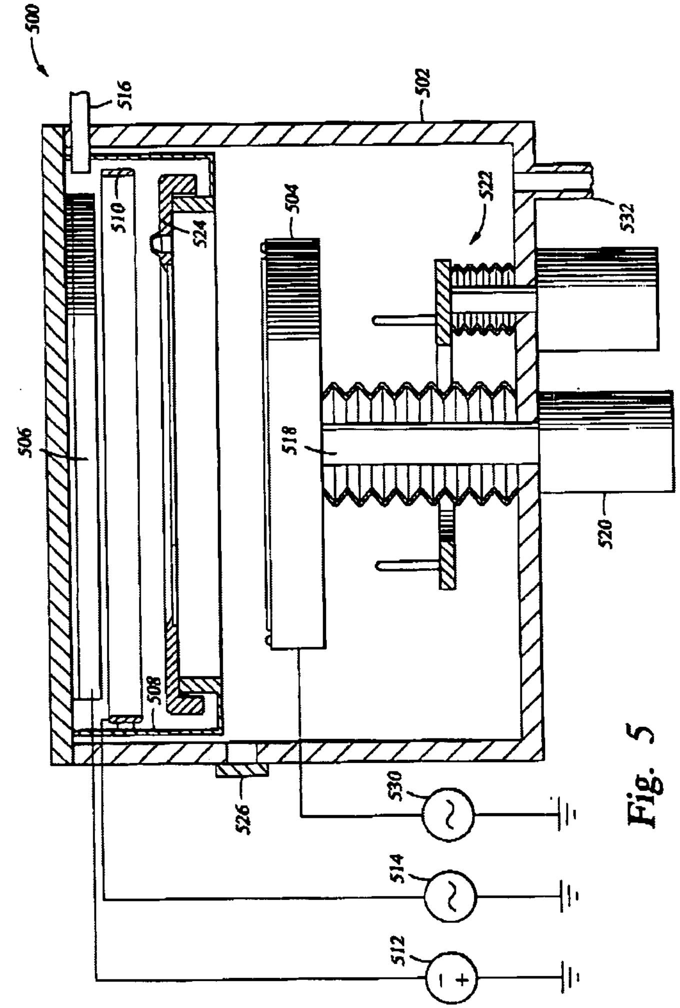

Fig. 5

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24	US 6516233 B1	15	☐	☐	☐	☐	☐	☐	☑	☐	☐		USPAT
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US-PAT-NO: 6508920

DOCUMENT-IDENTIFIER: US 6508920 B1
See image for Certificate of Correction

TITLE: Apparatus for low-temperature annealing of metallization microstructures in the production of a microelectronic device

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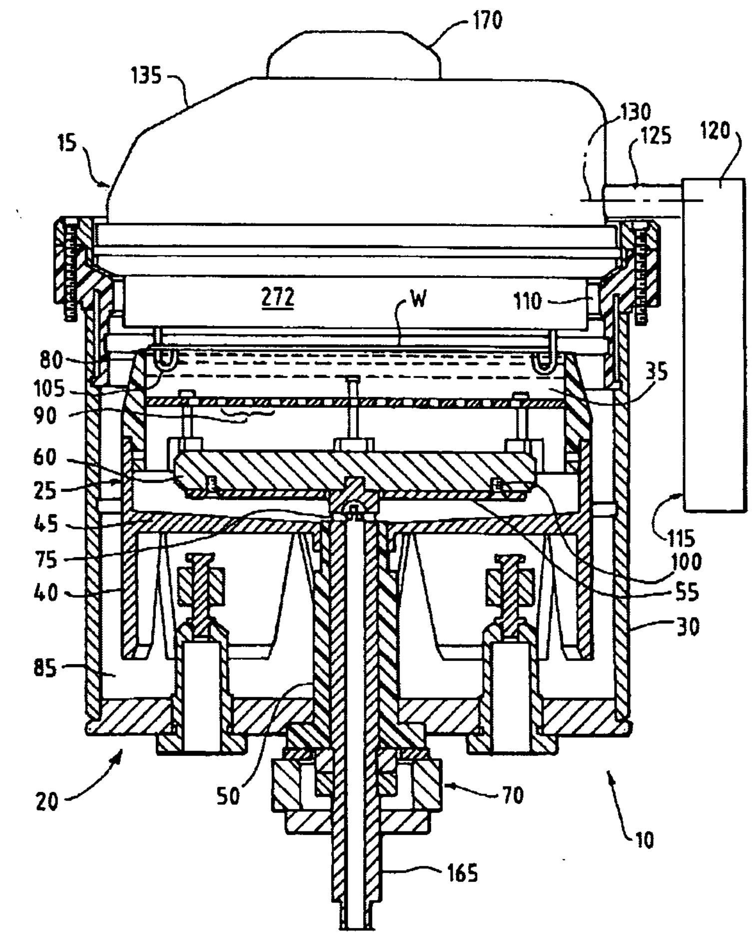
Current US Cross Reference Classification - CCXR (5):
204/224R

U.S. Patent Jan. 21, 2003 Sheet 1 of 7 **US 6,508,920 B1**

FIG. 1



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US-PAT-NO: 6497801

DOCUMENT-IDENTIFIER: US 6497801 B1
See image for Certificate of Correction

TITLE: Electroplating apparatus with segmented anode array

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Current US Cross Reference Classification - CCXR (1):
204/224R

FIG. 3

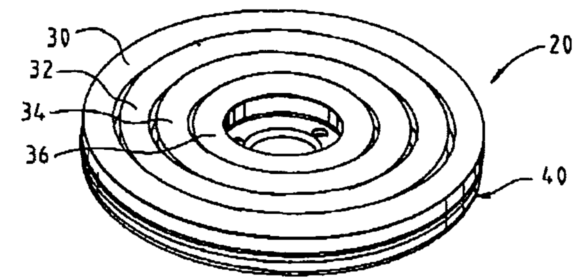


FIG. 4

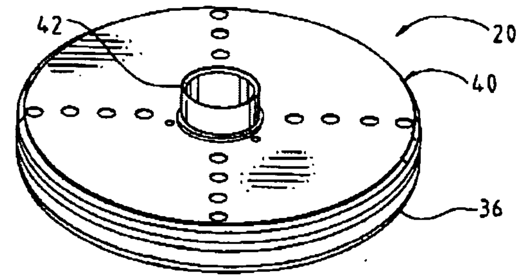
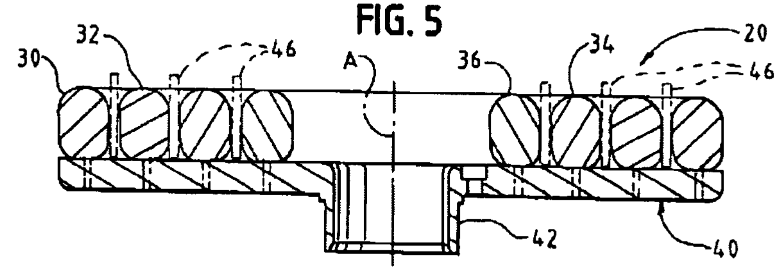


FIG. 5



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26	US 6508926 B1	12	☐	☑	☐	☐		USPAT
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US-PAT-NO: 6497801

DOCUMENT-IDENTIFIER: US 6497801 B1
See image for Certificate of Correction

TITLE: Electroplating apparatus with segmented anode array

---------- KWIC ---------

Current US Cross Reference Classification - CCXR (1):
204/224R

arranged in concentric relationship with each other. As is known in the art, the anode segments may be consumable, whereby metal ions of the anode segments are transported by the electroplating solution to the electrically conductive surface of the associated workpiece, which functions as a cathode.

In this illustrated embodiment, the segmented anode array 20 includes four (4) anode segments, respectively designated 30, 32, 34 and 36. The anode segments are of relatively decreasing diameters, with the segments thus fitting one-within-the-other.

It is preferred that the anode segments be positioned in generally coplanar relationship with each other, with the segments coaxial with each other along axis "A". In order to maintain the segments in this relative disposition, the anode array 20 includes a mounting base 40 upon which each of the anode segments is mounted. The mounting base 40 includes a collar portion 42 which defines a flow passage for directing flow of electroplating solution through the mounting base. In this embodiment, the central-most one of the concentric anode segments defines an opening aligned with the axis "A" of the reactor vessel, with the flow passage defined by the collar portion of the mounting base 40 being aligned with the opening defined by this central-most one 36 of the anode segments.

Operation of this embodiment of the present invention contemplates that plating solution is pumped through inlet conduit 18, through the flow passage defined by collar portion 42 of mounting base 40, and through the center of the anode array so that the solution impinges upon the surface of the workpiece W. The plating rate at the surface of the workpiece ordinarily will vary radially due to the effect of the impinging solution on the hydrodynamic boundary layer. Compensation of this radial effect can be achieved by operating the anode segments at different electrical potentials. Such an arrangement is diagrammatically illustrated in FIG. 1a, wherein controls of the present electroplating apparatus include suitable wiring for independently operating the plurality of segments of the anode array 20. It is contemplated that not only can the various anode segments be operating at differing electrical potentials, they may also be operated for differing periods of time to optimize the uniformity of plating on the workpiece.

In addition to affecting plating uniformity by using different anode potentials, it is within the purview of the present invention to affect uniformity by the disposition of dielectric (insulating) elements between adjacent ones of the anode segments. This is illustrated in phantom line in FIG. 5, wherein dielectric elements 46 are positioned between each adjacent pair of the anode segments 30, 32, 34 and 36.

The geometry of the dielectric elements can be modified to provide the desired effect on plating. Relatively tall geometries, i.e., dielectric elements which project significantly above the associated anode segments, are believed to tend to limit interaction of adjacent ones of the anode segments, and can tend to collimate solution flow to the workpiece. In contrast, shorter or perforated geometries are believed to tend to increase anode segment interaction. While the illustrated embodiments of the present invention show the anode segments positioned in coplanar relationship with each other, and thus, in generally equidistant relationship to the workpiece W, it is believed that an increase or decrease in anode segment interaction can also be achieved by positioning the ring-like anode segments at varying distances from the surface of the workpiece.

Depending upon the type of electroplating process, the segments of the anode array may be either consumable, or non-consumable. For those applications requiring a consumable anode, the anode segments can be formed from copper, such as phosphorized copper. In contrast, non-consumable anode segments can be formed from platinum plated titanium.

It is contemplated that suitable mechanical fasteners (not shown) be employed for individually securing each of the anode segments to the associated mounting base 40. Additionally, suitable sealed wiring (not shown) is provided for individually electrically connecting each of the anode segments with associated controls of the electroplating apparatus, whereby the electrical potential created by each anode segment can be independently varied and controlled. In this embodiment, it is contemplated that no perforate diffuser member be employed positioned between the anode array 20 and the workpiece W. Solution flow rate and current distribution can be controlled independently of one another to optimize the plating process and promote uniformity of deposition of electroplated metal. Air bubbles introduced into the plating chamber by the incoming plating solution are flushed past the workpiece surface, and thus will not interfere with the plating process. Venting of the workpiece surface, by its angular disposition as discussed above, may also be effected. Solution flow from the center of the anode array insures that the workpiece surface will be wetted from the center to the periphery. This prevents air from being trapped at the center of the workpiece when it first contacts the surface of the solution.

As will be appreciated, the use of a segmented anode array having circular anode segments is particularly suited for use with circular, disk-like wafers or like workpieces. However, it is within the purview of the present invention that the anode array, including the anode segments, be non-circular.

With reference now to FIGS. 6–9, therein is illustrated an alternate embodiment of the present segmented anode array. In this embodiment, elements which generally correspond to those in the above-described embodiment are designated by like reference numerals in the one-hundred series.

Segmented anode array 120 includes a plurality of ring-like anode segments. In this embodiment, five (5) of the anode segments are provided in concentric relationship with each other, including segments 130, 132, 134, 136 and 138.

The anode array 120 includes a mounting base 140 having a plurality of divider elements 141 respectively positioned between adjacent ones of the circular anode segments. As in the previous embodiment, the anode segments are positioned in coplanar relationship with each other on the mounting base, and are positioned in coaxial relationship with the axis "A" of the associated reactor vessel.

In distinction from the previous embodiment, anode array 120 is configured such that flow of electroplating solution is directed generally about the periphery of the array. In particular, the mounting base 140 includes a plurality of circumferentially spaced depending flow-modulating projections 143 which define flow channels between adjacent ones of the projections. Electroplating solution is introduced into the reactor vessel through an inlet conduit 118, which defines a plurality of flow passages 119 generally at the upper extent thereof, beneath mounting base 140, and inwardly of flow-modulating projections 143. The solution then flows between the flow-modulating projections, and upwardly generally about the anode segments.

This embodiment illustrates a series of openings defined by mounting base 140. With particular reference to FIG. 8, those series of holes aligned at 120° intervals about the base

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4	US 6236163 B1	21	☑	☐		USPAT
5	US 5973447 A	33	☑	☐		USPAT
6	US 5969361 A	10	☑	☐		USPAT
7	US 5688393 A	10	☑	☐		USPAT

US-PAT-NO: 6565729

DOCUMENT-IDENTIFIER: US 6565729 B2

TITLE: Method for electrochemically depositing metal on a semiconductor workpiece

---------- KWIC ---------

Brief Summary Text - BSTX (19):
One embodiment of the invention provides a process for applying a metallization interconnect structure to a workpiece on which an ultra-thin metal seed layer has been formed using a first deposition process. The first deposition process anchors the ultra-thin metal seed layer to an underlying layer, the ultra-thin metal seed layer having physical characteristics that render it generally unsuitable for bulk electrolytic deposition of a metal onto the metal seed layer. The process entails repairing the ultra-thin metal seed layer by electrochemically depositing additional metal on the ultra-thin metal seed layer within a principal fluid chamber of a reactor to provide an enhanced seed layer using a second deposition process. The second deposition process, which is different from the first deposition process, entails supplying electroplating power to a plurality of concentric anodes disposed at different positions within the principal fluid flow chamber relative to the workpiece. After seed layer repair, additional metal is deposited in an electrolytic bulk plating process onto the enhanced seed layer, under conditions in which the deposition rate of the electrolytic deposition process is substantially greater than the deposition rate of the process used to repair the metal seed layer.

Brief Summary Text - BSTX (21):
Another embodiment of the invention provides a process for applying a metallization interconnect structure to a workpiece on which an ultra-thin metal seed layer has been formed using a first deposition process. The first deposition process anchors the ultra-thin metal seed layer to an underlying layer, the ultra-thin metal seed layer having physical characteristics that render it generally unsuitable for bulk electrolytic deposition of a metal onto the metal seed layer. The process entails subjecting the workpiece to an electrochemical deposition process that is different from the first deposition process, in an alkaline electroplating bath. The alkaline electroplating bath includes metal ions complexed with a complexing agent such that additional metal is deposited on the ultra-thin copper seed layer to thereby repair the seed layer. This results in an enhanced seed layer. The second deposition process is carried out by supplying electroplating power to a plurality of concentric anodes disposed at different positions, relative to the workpiece, within a principal fluid flow chamber of a reactor. Thereafter, additional metal is deposited on the enhanced seed layer using an electrolytic bulk deposition process under conditions in which the deposition rate of the electrolytic deposition process is substantially greater than the deposition rate of the process used to repair the metal seed layer.

Brief Summary Text - BSTX (25):
Another embodiment of the invention provides a process for applying a metallization interconnect structure to a workpiece on which an ultra-thin metal seed layer has been formed using a first deposition, process. The first

U.S. Patent May 20, 2003 Sheet 15 of 28 US 6,565,729 B2

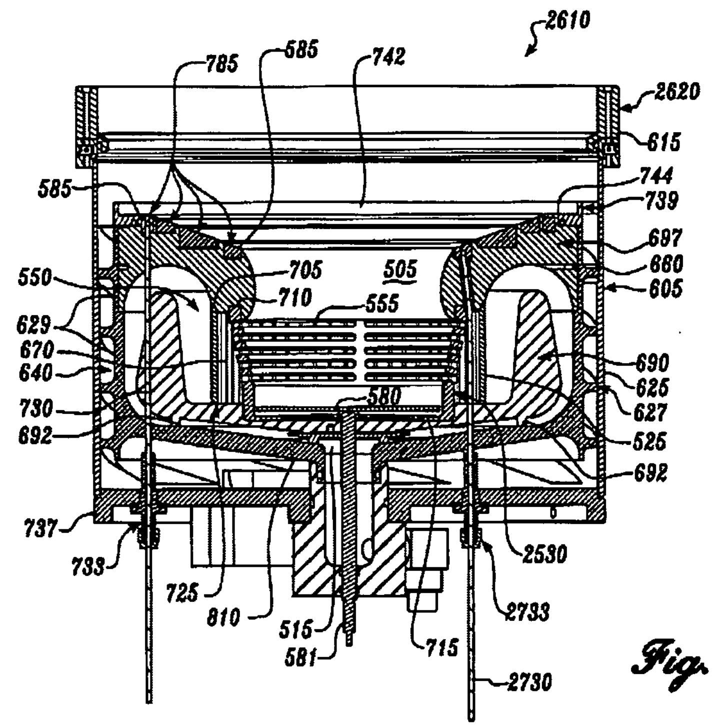

Fig. 11.

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4	US 6236163 B1	21	☑	☐	USPAT
5	US 5973447 A	33	☑	☐	USPAT
6	US 5969361 A	10	☑	☐	USPAT
7	US 5688393 A	10	☑	☐	USPAT

US-PAT-NO: 6565729

DOCUMENT-IDENTIFIER: US 6565729 B2

TITLE: Method for electrochemically depositing metal on a semiconductor workpiece

---------- KWIC ---------

Brief Summary Text - BSTX (19):
One embodiment of the invention provides a process for applying a metallization interconnect structure to a workpiece on which an ultra-thin metal seed layer has been formed using a first deposition process. The first deposition process anchors the ultra-thin metal seed layer to an underlying layer, the ultra-thin metal seed layer having physical characteristics that render it generally unsuitable for bulk electrolytic deposition of a metal onto the metal seed layer. The process entails repairing the ultra-thin metal seed layer by electrochemically depositing additional metal on the ultra-thin metal seed layer within a principal fluid chamber of a reactor to provide an enhanced seed layer using a second deposition process. The second deposition process, which is different from the first deposition process, entails supplying electroplating power to a plurality of concentric anodes disposed at different positions within the principal fluid flow chamber relative to the workpiece. After seed layer repair, additional metal is deposited in an electrolytic bulk plating process onto the enhanced seed layer, under conditions in which the deposition rate of the electrolytic deposition process is substantially greater than the deposition rate of the process used to repair the metal seed layer.

Brief Summary Text - BSTX (21):
Another embodiment of the invention provides a process for applying a metallization interconnect structure to a workpiece on which an ultra-thin metal seed layer has been formed using a first deposition process. The first deposition process anchors the ultra-thin metal seed layer to an underlying layer, the ultra-thin metal seed layer having physical characteristics that render it generally unsuitable for bulk electrolytic deposition of a metal onto the metal seed layer. The process entails subjecting the workpiece to an electrochemical deposition process that is different from the first deposition process, in an alkaline electroplating bath. The alkaline electroplating bath includes metal ions complexed with a complexing agent such that additional metal is deposited on the ultra-thin copper seed layer to thereby repair the seed layer. This results in an enhanced seed layer. The second deposition process is carried out by supplying electroplating power to a plurality of concentric anodes disposed at different positions, relative to the workpiece, within a principal fluid flow chamber of a reactor. Thereafter, additional metal is deposited on the enhanced seed layer using an electrolytic bulk deposition process under conditions in which the deposition rate of the electrolytic deposition process is substantially greater than the deposition rate of the process used to repair the metal seed layer.

Brief Summary Text - BSTX (25):
Another embodiment of the invention provides a process for applying a metallization interconnect structure to a workpiece on which an ultra-thin metal seed layer has been formed using a first deposition, process. The first

U.S. Patent May 20, 2003 Sheet 17 of 28 US 6,565,729 B2

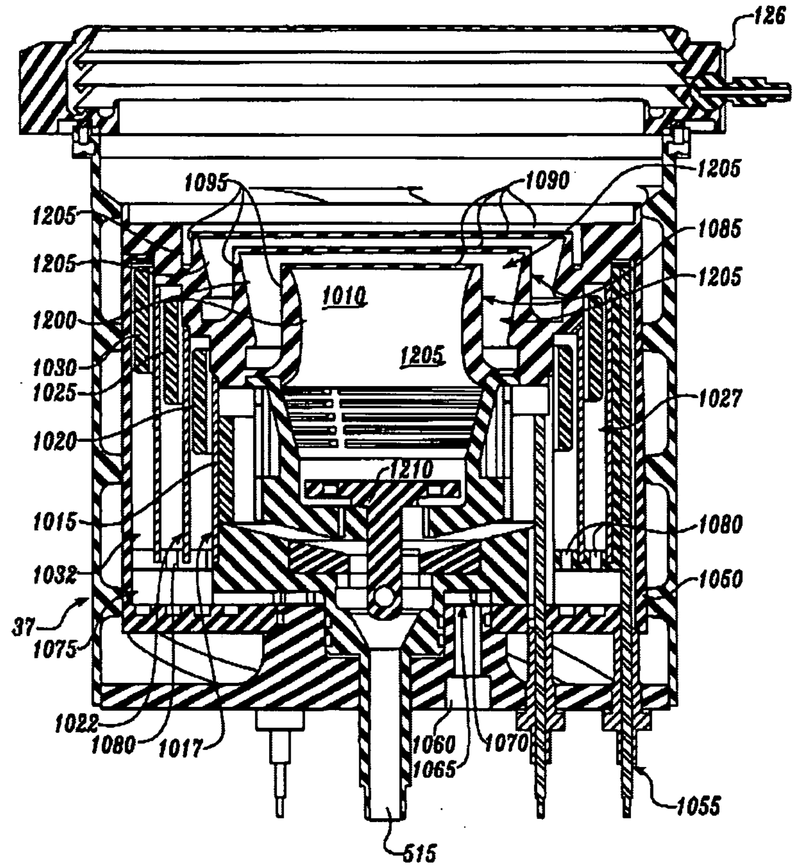

Fig. 13.

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	Document ID	Pages		Kind Codes	Sou
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34	US 6478935 B1	16			USPAT
35	US 6475357 B2	11			USPAT
36	US 6454926 B1	63			USPAT

US-PAT-NO: 6454926

DOCUMENT-IDENTIFIER: US 6454926 B1
See image for Certificate of Correction

TITLE: Semiconductor plating system workpiece support having workpiece-engaging electrode with submerged conductive current transfer areas

---------- KWIC ---------

Current US Cross Reference Classification - CCXR (1):
204/224R

(12) **United States Patent**
Ritzdorf et al.

(10) Patent No.: **US 6,454,926 B1**
(45) Date of Patent: ***Sep. 24, 2002**

(54) **SEMICONDUCTOR PLATING SYSTEM WORKPIECE SUPPORT HAVING WORKPIECE-ENGAGING ELECTRODE WITH SUBMERGED CONDUCTIVE CURRENT TRANSFER AREAS**

(75) Inventors: **Thomas L. Ritzdorf; Jeffrey I. Turner; Robert W. Berner**, all of Kalispell, MT (US)

(73) Assignee: **Semitool Inc.**, Kalispell, MT (US)

(*) Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **08/940,669**

(22) Filed: **Sep. 30, 1997**

(51) Int. Cl.^{7} **C25D 5/00**; C25D 17/06

(52) U.S. Cl. .... 205/96; 204/224 R; 204/290.11; 204/297.01; 204/297.14; 204/DIG. 7; 205/123

(58) Field of Search .... 205/96, 123, 137, 205/143, 157; 204/280, 286, 297 R, 297 W, DIG. 7, 224 R, 288.1, 288.3, 297.01, 297.14, 290.11

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,267,010 A		8/1966	Creutz et al.	
3,328,273 A		6/1967	Creutz et al.	
3,655,549 A	*	4/1972	Wild	204/297 R
3,770,598 A		11/1973	Creutz	
3,832,291 A		8/1974	Arcilesi et al.	
4,110,176 A		8/1978	Creutz et al.	
4,336,114 A		6/1982	Mayer et al.	
4,374,709 A		2/1983	Combs	
4,789,648 A	*	12/1988	Chow et al.	437/225
5,078,852 A		1/1992	Yee et al.	
5,167,792 A		12/1992	Kamitakahara et al.	
5,258,047 A		11/1993	Tokisue et al.	
5,312,532 A		5/1994	Andricacos et al.	
5,368,711 A	*	11/1994	Poris	204/193
5,391,285 A	*	2/1995	Lytle et al.	205/123
5,405,518 A		4/1995	Hsieh et al.	
5,522,975 A		6/1996	Andricacos et al.	

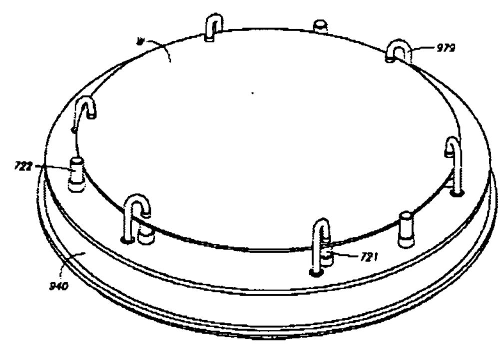
* cited by examiner

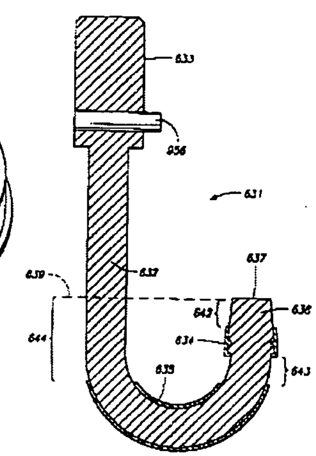
Primary Examiner—Donald R. Valentine
Assistant Examiner—William T. Leader
(74) *Attorney, Agent, or Firm*—Perkins Coie LLP

(57) **ABSTRACT**

A semiconductor workpiece holder used in electroplating systems for plating metal layers, such as copper, onto a semiconductor workpiece. The workpiece holder includes electrodes which extend and are partially submerged in a liquid plating bath. The electrodes have a contact face which bears against the workpiece and conducts current therebetween. The submersible portions of the electrodes are partially covered with a dielectric layer or surface and partially covered with a conductive layer or surface. The conductive surface is preferably spaced from the contact face and placed in direct contact with the plating bath to allow diversion of some of the plating current directly between the electrode and plating bath. Associated methods are also described.

44 Claims, 38 Drawing Sheets





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US-PAT-NO: 6497801

DOCUMENT-IDENTIFIER: US 6497801 B1
See image for Certificate of Correction

TITLE: Electroplating apparatus with segmented anode array

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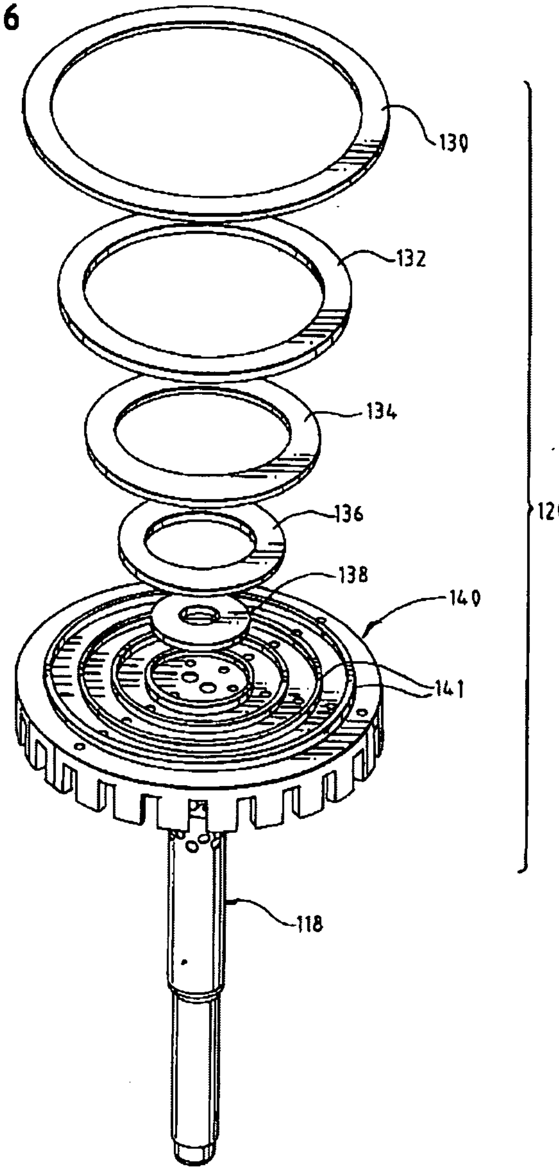
Current US Cross Reference Classification - CCXR (1):
204/224R

U.S. Patent Dec. 24, 2002 Sheet 4 of 7 US 6,497,801 B1

FIG. 6



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US-PAT-NO: 6391166

DOCUMENT-IDENTIFIER: US 6391166 B1

TITLE: Plating apparatus and method

---------- KWIC ---------

US Patent No. - PN (1):
6391166

wafer 31. The gap size is in a range of 0.1 mm to 5 mm, and preferably 1 mm. The process sequence is similar to that of the FIG. 30 embodiment.

FIGS. 33A–33B show another embodiment of apparatus for plating a conductive film in accordance with the present invention. The embodiment of FIGS. 33A–33B is similar to that of FIGS. 32A–32B except that fresh electrolyte is input from the center of the bath through pipes 260 instead of anode jets 254 through flexible pipe 258. Wafer 31 is also immersed into the electrolyte. Similarly, a movable anode is placed very close to wafer 31 in order to focus plating current on a portion of wafer 31. The gap size is in a range of 0.1 mm to 5 mm, and preferably 1 mm. The process sequence is similar to that of FIG. 30.

FIGS. 34A–34D show four embodiments of movable anodes in accordance with the present invention. FIG. 34A shows an anode structure consisting of anode 252 and case 262. Case 262 is made of insulator materials such as tetrafluoroethylene, PVC, PVDF, or polypropylene. FIG. 34B shows an anode structure consisting of anode 266 and case 264. The electrolyte is feed through a hole at the bottom of case 264. FIG. 34C shows an anode structure consisting of anode 262, electrodes 274 and 270, insulator spacer 272 and case 262, and power supplies 276, 268. Electrode 274 is connected to negative output of power supply 276, and electrode 270 is connected to cathode wafer 31. The function of electrode 274 is to trap any metal ions flowing out of case 262, therefore no film is plated on the wafer area outside of case 262. The function of electrode 270 is to prevent electrical field leakage from electrode 274 to minimize any etching effect. The embodiment of FIG. 34D is similar to that of FIG. 34C except that the case 264 has a hole at the bottom for electrolyte to flow through.

FIG. 35 shows the surface status of a wafer during plating. Wafer area 280 was plated by a seed layer, area 284 is in the process of plating, and wafer area 282 has not been plated.

FIGS. 36A–36C show an additional three embodiments of apparatus for plating a conductive film in accordance with the present invention. The embodiment of FIG. 36A is similar to that of FIGS. 30A–30B except that the number of bars is increased to three. The angle between two adjacent bars is 60°. The embodiment of FIG. 36B is similar to that of FIGS. 30A–30B except that the number of bars is increased to four. The angle between two adjacent bars is 45°. The embodiment of FIG. 36C is similar to that of FIGS. 30A–30B except that the number of bars is reduced to 0.5, i.e. half a bar. Alternatively, the number of bars can be 5, 6, 7 or more.

The embodiment of FIG. 36D is similar to that of FIGS. 30A–30B except that the shape of bar 250 is a spiral instead of a straight line. Movable anode jet 254 is movable along the spiral bar so that good plating uniformity can be achieved without rotating the wafer. This simplifies the wafer chuck mechanism.

FIGS. 37A and 37B show additional two embodiments of apparatus for plating a conductive film in accordance with the present invention. The embodiments of FIG. 37A and 37B are similar to that of FIGS. 30A–30B, except that the wafer is placed upside down and vertically, respectively.

FIGS. 38A–38B show another embodiment of apparatus for plating a conductive film in accordance with the present invention. The embodiment of FIGS. 38A–38B is similar to that of FIGS. 16A–16B except that all of the anodes are replaced by a one piece anode 8. Anode 8 is connected to single power supply 11. Plating process steps using this embodiment are described as follows:

9A. Process Steps for Plating Conductive Film (or Seed Layer) Directly on Barrier Layer.

Step 1: Turn on LMFC 21. and valves 82, 83, and 84 and turn off LMFCS 22, 23, 24 and valve 81, so that electrolyte only touches the portion of the wafer above sub-plating bath 66, and then flows back to tank 36 through the return paths of spaces between cylindrical walls 100 and 103, 105 and 107, 107 and 109, and tube 109.

Step 2: After the flow of electrolyte is stabilized, turn on power supply 11. Positive metal ions will be plated onto the portion of wafer 31 above sub-plating bath 66.

Step 3: When the thickness of the conductive film reaches the predetermined set-value or thickness, turn off power supply 11 and turn off LMFC 21.

Step 4: Repeat step 1 to 3 for LMFC 22 (turn on LMFC 22, valves 81, 83, 84, and power supply 11, and turn off LMFCs 21 23, 24, valve 82).

Step 5: Repeat step 4 for LMFC 23 (turn on LMFC 23, valves 81, 82, 84, and power supply 11, and turn off LMFCs 21, 22, 24, valve 83).

Step 6: Repeat step 4 for LMFC 24 (turn on LMFC 24, valves 81, 82, 83, and power supply 11, and turn off LMFCs 21, 22, 23 and valve 84).

In the above seed layer plating process, instead of plating from the periphery of the wafer to the center of the wafer, the plating also can be performed from the center to the periphery, or can be performed in a randomly chosen anode sequence.

9B. Process Steps for Succeeding Metal Plating on the Metal Seed Layer Plated in Process 9A.

Step 7: Turn on LMFCs 21, 22, 23 and 24 and turn off valves 81, 82, 83, 84. In principle, the flow rate of electrolyte from each LMFC is set as proportional to the wafer area covered by the corresponding LMFC.

Step 8: After all flows are stabilized, turn on power supply 11.

Step 9: Turn off power supply 11 when the film thickness reaches the set-value.

LMFCs can be turned off at different times in order to adjust the plating film thickness uniformity as shown in FIG. 39. At time t_1, only LMFCs 21, 23, and 24 are turned off, and valves 81, 83, and 84 are also turned off. Therefore, electrolyte does not touch the wafer except in the area above sub-plating bath 64. As the power supply 11 remains turned on, metal ions will be plated only on the area above sub-plating bath 64. Then LMFC 22 turns off at time t_2. Similarly, LMFC 24 turns on at time t_3 and turns off at time t_4 to obtain extra plating at the wafer area above sub-plating bath 60. Turn off time of t_2 and t_4 can be fine tuned by measuring wafer thickness uniformity.

FIGS. 40A–40B show another embodiment of apparatus for plating a conductive film in accordance with the present invention. The embodiment of FIGS. 40A–40B is similar to that of FIGS. 3A–3B except that all anodes are connected to single power supply 11. Since the electrolyte only touches the portion of wafer above an anode during the seed layer plating process, the plating current will only pass through the anode and go to that portion of the wafer. The plating process steps are similar to those of FIGS. 3A–3B with power supply 11 replacing power supplies 12 and 13.

FIGS. 41A–41B show another embodiment of apparatus for plating a conductive film in accordance with the present invention. The embodiment of FIGS. 41A–41B is similar to that of FIGS. 40A–40B except that the cylindrical walls can move up and down to adjust the flow pattern. As shown in